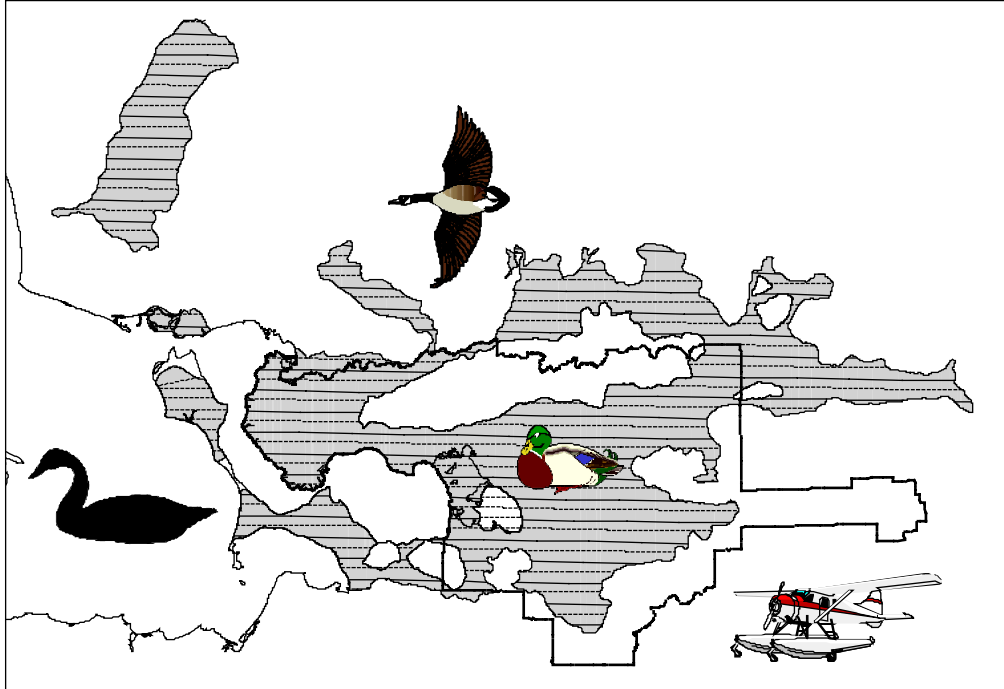


**WATER BIRD ABUNDANCE AND DISTRIBUTION
ON SELAWIK NATIONAL WILDLIFE REFUGE AND NOATAK LOWLANDS,
ALASKA, 1996-1997**



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ALASKA, 1996-1997**

by

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Key words: abundance, aerial surveys, Alaska, Selawik National Wildlife Refuge, density, distribution, estimates, geographic information system, mapping, Noatak Lowlands, population indices, water birds, waterfowl

Data and conclusions presented here are preliminary and are not for publication or citation without permission from the author.

EXECUTIVE SUMMARY

Surveys were flown to estimate abundance and map distribution of water birds in June 1996 and 1997 on Selawik National Wildlife Refuge (SNWR) and nearby Noatak Lowlands. An estimated 354,000 ducks, 30,000 geese, and 4,000 loons were present on the survey area in June 1996. American wigeon were the most numerous ducks comprising 35% of the duck population. Other abundant species included scaup, northern pintails, and green-winged teal. Coefficients of variation for population indices of abundant species ranged from 9-17%. Estimates for the 1997 survey were 268,000 ducks, 24,000 geese, and 2,000 loons. Northern pintails were most abundant with 25% of the duck population followed by scaup, wigeon, and green-winged teal in decreasing order of abundance. Population sizes of American wigeon were considerably different between years, being about 2.5 times larger in 1996. Similarly, the green-winged teal population estimate for 1996 was almost twice that for 1997. Generally, dabbling populations were higher in 1996 than in 1997. Conversely, Oldsquaw and scoter numbers were greater in 1997 than in 1996. The 1996 survey was flown in mid- to late- June whereas the 1997 survey was flown in early June. It is unclear if these yearly differences in population size are directly related to survey timing.

A computerized geographic information system (GIS) was used to map bird locations and densities for most species. The highest concentrations of waterfowl occurred on the Noatak and Kobuk River deltas as well as the habitat east of Selawik Lake along the Selawik and Tagagawik rivers. Densities were generally lower for the Noatak Lowlands and the area north of the Waring Mountains. Scaup were the most widely distributed species occurring over most of the survey area. Density maps were created only for species with sufficient observations. Point location maps only are presented for species observed infrequently.

The aerial survey systematic design and GIS analyses provide detailed water bird abundance and distribution information. Results can be compared to those from the North American Waterfowl Breeding Population Survey on SNWR to evaluate both designs and improve subsequent surveys to meet specific objectives. Region 7, Division of Realty has used the water bird density maps in their Acquisition Priority System model. Maps can be used as data layers for further analyses such as creating stratified survey designs and examining relationships between remotely sensed habitat data and water bird distribution.

INTRODUCTION

An aerial waterfowl breeding population survey was initiated in 1957 and has been conducted annually on the SNWR as part of the North American Waterfowl Breeding Population Survey (NAWBPS) (Conant and Groves 1998). The purpose of the NAWBPS is to provide population indices for use in developing waterfowl harvest regulations. Intensity of coverage on SNWR by this survey is limited since it is only one of 12 strata surveyed annually by one crew in Alaska and the Yukon Territory. On SNWR, the survey consists of seven transects totaling 300 km. Transect placement was based on landmarks as aids in navigation to ease annual repeatability of the survey. Consequently, important habitats may not have been adequately sampled or conversely, could have been oversampled. Thus, non-random placement of transects may result in biased estimates of bird abundance. Also, because NAWBPS data are recorded by 16-mile segments along each transect, these data provide limited information on water bird distribution.

Within the last 10 years, several improvements and advancements in technology have been incorporated into designing and conducting aerial surveys and analyzing data in Alaska by Migratory Bird Management. We began by using a statistically valid standard survey design with systematically spaced transects following suggestions of Caughley (1977). We developed a geographic information system consisting of custom True BASIC programs and PC ARC/INFO software which allowed us to generate a set of transects for any geographic area and plot them on topographic maps for use in the aircraft. Use of a Global Positioning System (GPS), enabled us to accurately navigate systematic transects. We also used a technique to obtain geographic coordinates of every bird observation using continuously running cassette recorders and a computerized data entry program developed by Butler et al. (1995a). Another recent improvement is a new data collection program that eliminates the need for continuously running tapes developed by Jack Hodges (Migratory Bird Management, Juneau). Bird location data have been entered into the GIS allowing mapping of species density (Butler et al. 1995b) as well as further analyses such as developing stratifications for population estimates or overlays with habitat information.

This system has been used on the Innoko area (Platte 1996), Bristol Bay region (Platte and Butler 1995), Yukon Flats National Wildlife Refuge (Platte and Butler 1992), Yukon Delta National Wildlife Refuge (Balogh and Butler 1994, Platte and Butler 1993), Copper River Delta (Butler and Eldridge 1991), the west coast of Alaska, and the arctic coastal plain of Alaska (Brackney and King 1993, Larned and Balogh 1993). Improvements include increased precision in population indices, greater resolution in density distribution maps, and calculation of population indices on desired land parcels such as federal versus non-federal land.

The objectives for the expanded aerial breeding population survey on SNWR were as follows:

1. Estimate the abundance of water birds.
2. Map the distribution of water birds.
3. Compare the new survey design with the traditional design.

Comparison of the expanded breeding population survey results with those of the NAWBPS and development of an improved survey design will be addressed in a future report.

STUDY AREA

Selawik National Wildlife Refuge occupies about 3 million acres east of Kotzebue Sound in northwestern Alaska (Fig. 1). The area surveyed for water birds extended 130 km north to south and 300 km east to west encompassing about 15,000 km² of the refuge wetlands and the wetlands along the Noatak River corridor to the northwest. The refuge contains an abundance of wetlands including the estuaries and brackish lakes of the Selawik and Kobuk River deltas and the extensive ponds, marshes and streams of the Selawik lowlands inland along the Selawik River. The streams in the area are sluggish, meandering, of moderately low gradient, and have numerous side sloughs. There are numerous large thaw lakes occupying the lowlands around the Selawik River.

The climate of the area is generally maritime in summer with average temperature about 60 degrees Fahrenheit but with long cold periods during the winter (U.S. Fish and Wildlife Service 1987). The lowlands receive about 15-20 inches of precipitation annually with most occurring in the wet summer months of July and August. The region is affected by strong persistent west winds in the summer which lasts from mid-June to early September however June and early July are usually dominated by clear skies. Annual production of waterfowl depends upon the lateness of spring and the amount of flooding.

METHODS

Aerial Survey Techniques

The traditional NAWBPS transects are shown in Figure 2. For the expanded breeding population survey, we used a True Basic program and PC ARC/INFO to generate systematically spaced transects from a random coordinate within the predetermined survey area. Transects were oriented from east to west along great circle routes and totaled about 2,000 kms each year (Fig. 2). One set of flightlines was flown in 1996 and the alternate set was flown in 1997. Systematic sampling was appropriate for the dual objectives of mapping distributions and estimating total numbers when accuracy of the estimate's standard error was not critical (Caughley 1977). We divided transects into 14.8 km segments to facilitate data recording and plotted transects and segments on 1:250,000 scale topographic maps for use in the aircraft. Distance between transects was 7.4 km resulting in a sample of about 800 km² (5%) of the 15,000 km² survey area each year. The upper Baldwin Peninsula south of Kotzebue was surveyed in 1997 but not in 1996.

Data for both years were combined to produce species distribution maps.

Survey methods followed the conventions established for breeding ground surveys in North America (USFWS and CWS 1987). The survey was flown from 18 - 21 June 1996 and 4 - 8 June 1997 to coincide with egg-laying or early incubation stages of breeding waterfowl. The aircraft was flown at 137 - 153 km hr⁻¹, 30 - 46 m of altitude, with wind speed < 24 km hr⁻¹, ceilings > 152 m and visibility > 16 km. The pilot used a global positioning system and the survey maps to maintain a precise course while flying transects.

The pilot and observer recorded transect numbers, segment numbers, segment start and stop points, cardinal direction of the start end of the segment, and bird observations on continuously running cassette tapes for the 1996 survey. Birds observed were identified to species and counted as a single, pair, or number in flock.

In 1996, geographic coordinates of each observed bird were calculated using a technique developed by Butler et al. (1995a). Tapes were replayed and data were entered simultaneous with the recording into a computer in real time using a True BASIC program. Distances along segments to observations were calculated based on elapsed time to an observation in proportion to elapsed time to fly the segment of known length. These observation distances were then converted to geographic coordinates using another True BASIC program.

A new data collection program called Global Positioning System Voice Survey written by Jack Hodges (Migratory Bird Management, USFWS, Juneau) was used in 1997. This system uses a notebook computer connected with a global positioning system (GPS) receiver and a remote microphone. Bird observations were recorded directly into the computer to a .WAV format sound file using the remote microphone while simultaneously latitude/longitude coordinates for each observation were automatically downloaded from the GPS to a text file. A data transcription program was used to play the sound files, enter header information, species codes, group sizes and combine these with the coordinate information to produce a final data file.

Bill Larned and Greg Balogh were the observers for the 1996 survey while Jack Hodges and Alan Brackney collected the data in 1997.

Population estimates

We calculated densities, population estimates and variability for each species using a ratio estimate described by Cochran (1977). Estimates were based on indicated total birds: $2*(S+P)+F$ where S = number of single birds observed, P = number of bird pairs observed, and F = number of birds in flocks. For ducks, a single male was assumed to represent a breeding pair with the nesting

hen not easily observable. Single male ducks were doubled for all observed species except scaup. Single observations of other water bird species (geese, swans, cranes, grebes, loons, terns, and gulls) were not doubled. Numbers of ducks were corrected for visibility bias using correction factors from Conant and Groves (1992). Numbers for other water bird species were not corrected for visibility bias. Population estimates were calculated for each year separately and with data for both years combined to produce average estimates. Estimates were calculated for the entire survey area as a whole and for the survey area divided into several large geographic strata (Fig. 3).

Population estimate variance was based on the variation among sampling units (entire transects). The sample size (number of transects) was 88 in 1996 and 90 in 1997. The additional variance associated with visibility correction factors was not included in our calculations.

Water bird distribution

We produced water bird density distribution maps using a GIS technique that differed from the technique developed by Butler et al. (1995b) that was used for previous surveys. However, the GIS technique produced similar results. Similarly to both techniques, geographic coordinates of observed birds were calculated in True BASIC by combining transect position and length files with bird observation files. A moving average technique (Eberhardt and Thomas 1991) was used to convert the bird groups to bird density. Instead of using a True BASIC program as in the past, we used GIS to calculate bird density in sequential 4000 meter blocks along each transect. Densities in blocks at the ends of transects were based on blocks less than 4000 meters in length because transects were not equally divisible by 4000. The resulting location and density data were converted to a triangulated irregular network (TIN), then to a grid and finally to a choropleth (patterned polygon) map of water bird density for abundant species using ARC/INFO. Low, medium and high density levels correspond to the lower, middle and upper 33% quantiles of the cumulative density for each species. Density values were based on indicated total birds uncorrected for visibility bias because geographic distribution of the bias is unknown.

RESULTS AND DISCUSSION

Population estimates

The number of ducks of each species observed were initially summarized into 4 groups: single drakes, pairs, birds in small flocks (groups of 3 or 4 birds), and birds in large flocks (groups of 5 or more birds) (Table 1). The proportion of singles and paired birds to flocked birds can be indicative of the breeding segment of the population. We present population estimates based on a simple expansion of the density by the amount of surveyed area in Tables 1 and 2. Tables 3 and 4 contain population estimates based on expansion of the densities within 5 geographic strata. This stratified analysis was done to try to reduce the variance of the estimates. Finally, Table 5 presents the average population estimates based on the stratified design with combined 1996-1997 data.

The population estimate for ducks in 1996, 354,000, was larger than in 1997 with 268,000 mostly due to the large number of wigeons in 1996 (Fig. A). American wigeon were the most abundant ducks in 1996 with over 124,000 birds and a mean density slightly over 8/km². They accounted for about 35% of the estimated duck population. About 72,000 pintails (about 5/km²) and 62,000 scaup (4/km²) were estimated for each year. The proportion of the population for other species in 1996 was 20% pintail, 17% scaup, 10% green-winged teal, 6% mallard, 6% northern shoveler, 3% black scoter, 2% oldsquaw, and 1% red-breasted merganser. Coefficients of variation were lowest for scaup, black scoters, oldsquaw, green-winged teal, and wigeon ranging from 9 – 17%. Variability was relatively high for other duck species. The estimated goose population of 30,000 was comprised

of 61% Canada geese and 39% white-fronted geese in 1996.

Pintails and scaup were the most numerous ducks in 1997, followed by wigeon. Of the 268,000 estimated ducks in 1997, species composition was 25% pintail, 23% scaup, 19% wigeon, 7% green-winged teal, 7% mallard, 7% shoveler, 5% black scoter, and 4% oldsquaw. Coefficients of variation were between 8 and 18% for most of the duck species. Canada geese were 54% of the total goose population of 24,000, compared to 46% white-fronts.

Average duck density on SNWR 1996-1997 was about 21/km² (Table 6). Duck densities on the Selawik area were intermediate between those on the Yukon Delta (16/km²) and the Yukon Flats (24/km²) and much higher than the arctic coastal plain. The wetland habitats of the Selawik area are more similar to those of the Yukon Delta and the Yukon Flats than of the arctic coastal plain because of less severe climatic conditions (Lensink and Rothe 1986).

Water bird distribution

More than 8,000 geographic locations of birds were obtained from the 1996-1997 surveys. Water bird locations and density polygons were mapped for the major species occurring on the survey area (Figs. 4-25). While most species were widely distributed throughout the survey area, the highest concentrations of waterfowl occurred between the Waring Mountains and the southern refuge border particularly along the Selawik River and the Tagagawik River. Large numbers of birds were also using the Kobuk Delta wetlands and the Noatak River delta. The Noatak River delta had good numbers of dabblers, scaup, scoters, and tundra swans. The Noatak River Lowlands in the northwestern portion of the survey area contained mostly pintails, scaup, Canada geese and white-fronted geese. A small portion of the base of the Peninsula bordering Kotzebue Sound contained concentrations of pintails, wigeon, shovelers, scaup and Canada geese.

Scaup were the most widely distributed species occurring over most of the survey area. Pintails were most abundant on the Kobuk and Noatak River delta wetlands. Oldsquaw occurred on the wetlands south of Kotzebue on the Baldwin Peninsula and were also scattered along the Selawik and Tagagawik River wetlands. Scoters were most abundant in the central portion of the survey area extending east of Selawik Lake and south of the Selawik River. The area on either side of the Selawik River east of the confluence of the Tagagawik River harbored concentrations of Canada and white-fronted geese. Sandhill cranes preferred the coastal fringe of the Kobuk River delta.

Several areas had lower densities for most species including much of the area north of the Waring Mountains, the area between the Waring Mountains and Selawik Lake, and the upper Kobuk River. Generally, densities decreased farther up the river corridors, up the smaller drainages, and as elevation increased toward the survey area periphery.

RECOMMENDATIONS

Accurate water bird abundance and distribution information over large geographic areas provides baseline information for management decision-making. The information can be used for land acquisition planning, mitigation planning, permit reviews, harvest regulation, and identification of unique ecological areas. Waterfowl density maps for the Yukon Delta and Yukon Flats National Wildlife refuges have been incorporated into the Division of Realty Acquisition Priority System model for ranking private lands within refuges for acquisition. Maps for SNWR will also be included in this model.

Analyses should be conducted to compare the results from this survey and the NAWBPS. This information is important for designing future surveys to meet specific objectives.

Migratory Bird Management has mapped water bird distribution and abundance on many of the important wetlands in Alaska using the survey techniques and geographic information system developed. However, important areas remain that have not been intensively surveyed. These areas could potentially be sampled in one year (given adequate time, money, personnel, and aircraft

availability) at sufficient intensity for detailed distribution mapping. We recommend that expanded surveys be conducted in these areas to contribute to a standardized water bird database for the State of Alaska.

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Table 1. Population estimates based on unstratified area surveyed by aerial survey in June 1996 on Selawik National Wildlife Refuge and adjacent wetlands.

Species	Birds				Indicated total birds ³	Visibility correction factor ⁴	Population estimate ⁵	Birds per sq. km.
	Drakes	No. of Pairs	in small flocks ¹	Birds in large flocks ²				
Mallard	91	14	0	63	273	4.01	20387	1.39
Northern pintail	159	56	18	781	1229	3.05	69806	4.76
Green-winged teal	52	54	4	16	232	8.36	36119	2.46
American wigeon	207	148	11	975	1696	3.84	121282	8.28
Northern shoveler	59	17	0	120	272	3.79	19198	1.31
Scaup*	509	362	13	437	1683	1.93	60490	4.13
Canvasback	1	0	0	5	7	2.43	317	0.02
Ring-necked duck*	1	3	0	0	7	4.02	524	0.04
Goldeneye	3	0	0	0	6	3.61	403	0.03
Bufflehead	1	0	0	0	2	1.86	69	< 0.01
Oldsquaw	42	32	0	5	153	1.87	5328	0.36
Black scoter	73	139	0	18	442	1.17	9631	0.66
Surf scoter	3	6	0	8	26	1.17	567	0.04
White-winged scoter	0	1	0	0	2	1.17	44	< 0.01
Common merganser	8	0	0	0	16	1.27	378	0.03
Red-breasted merganser	13	7	3	54	97	1.27	2294	0.16
Black brant*	1	0	0	0	1	N/A	19	< 0.01
Canada goose*	29	106	72	641	954	N/A	17766	1.21
White-fronted goose*	11	22	28	524	607	N/A	11304	0.77
Tundra swan*	138	113	6	449	819	N/A	15252	1.04
Sandhill crane*	27	20	4	6	77	N/A	1434	0.10
Red-necked grebe*	82	39	4	0	164	N/A	3054	0.21
Common loon*	1	2	0	0	5	N/A	93	0.01
Pacific loon*	53	57	3	0	170	N/A	3166	0.22
Red-throated loon*	19	12	0	0	43	N/A	801	0.05
Jaeger*	47	8	3	7	73	N/A	1359	0.09
Glaucous gull*	109	40	10	15	214	N/A	3985	0.27
Mew gull*	58	15	4	10	102	N/A	1900	0.13
Sabine's gull*	3	1	0	0	5	N/A	93	0.01
Arctic tern*	107	48	49	250	502	N/A	9349	0.64

1 Small flocks are defined as groups of 3 or 4 birds

2 Large flocks are defined as groups of 5 or more birds

3 T is indicated total birds = 2 * (singles + pairs) + flocks

4 V is the visibility correction factor

5 Population estimate = A * T/S * V

A = Square kilometers in survey area = 14,656

S = Square kilometers in sample = 787

* Single birds not doubled to calculate indicated total birds

Table 2. Population estimates based on unstratified area surveyed in June 1997 on Selawik National Wildlife Refuge and adjacent wetlands.

Species	Drakes	Birds		Birds		Indicated total birds ³	Visibility correction factor ⁴	Population Estimate ⁵	Birds per sq. km.
		No. of pairs	In Small flocks ¹	In Large flocks ²					
Mallard	65	35	0	46	246	4.01	18062	1.19	
Northern pintail	297	106	0	449	1255	3.05	70086	4.60	
Green-winged teal	46	16	0	8	132	8.36	20206	1.33	
American wigeon	229	88	0	90	724	3.84	50905	3.34	
Northern shoveler	91	36	3	24	281	3.79	19500	1.28	
Scaup*	382	500	0	360	1742	1.93	61560	4.04	
Canvasback	5	9	0	0	28	2.43	1246	0.08	
Ring-necked duck*	2	0	0	0	2	4.02	147	0.01	
Goldeneye	3	1	0	0	8	3.61	529	0.03	
Bufflehead	1	6	0	0	14	1.86	477	0.03	
Oldsquaw	110	45	0	51	361	1.87	12361	0.81	
Black scoter	80	186	0	112	644	1.17	13796	0.91	
Surf scoter	30	17	0	67	161	1.17	3449	0.23	
White-winged scoter	0	1	0	0	2	1.17	43	< 0.01	
Common merganser	7	2	0	0	18	1.27	419	0.03	
Red-breasted merganser	15	15	0	25	85	1.27	1977	0.13	
Common eider	0	1	0	0	2	3.58	131	0.01	
King eider	4	2	0	0	12	3.58	787	0.05	
Canada goose*	91	124	98	277	714	N/A	13073	0.86	
Emperor goose*	0	0	0	17	17	N/A	311	0.02	
White-fronted goose*	21	38	56	475	628	N/A	11499	0.75	
Tundra swan*	208	87	6	407	795	N/A	14557	0.96	
Sandhill crane*	50	19	8	8	104	N/A	1904	0.13	
Red-necked grebe*	84	22	7	0	135	N/A	2472	0.16	
Common loon*	2	3	0	0	8	N/A	146	0.01	
Pacific loon*	76	33	0	0	142	N/A	2600	0.17	
Red-throated loon*	5	3	0	0	11	N/A	201	0.01	
Yellow-billed loon*	1	1	0	0	3	N/A	55	< 0.01	
Jaeger*	64	5	6	21	101	N/A	1849	0.12	
Glaucous gull*	109	47	28	37	268	N/A	4907	0.32	
Mew gull*	12	8	3	25	56	N/A	1025	0.07	
Arctic tern*	86	33	39	220	411	N/A	7525	0.49	

1 Small flocks are defined as groups of 3 or 4 birds

2 Large flocks are defined as groups of 5 or more birds

3 T is indicated total birds = 2 * (singles + pairs) + flocks

4 V is the visibility correction factor

5 Population estimate = A * T/S * V

A = Square kilometers in survey area = 15,234

S = Square kilometers in sample = 832

* Single birds not doubled to calculate indicated total birds

Table 3. Water bird population indices based on 5 strata design (Fig. 3) from June 1996 aerial survey of Selawik National Wildlife Refuge, Alaska.

Species	Birds per sq. km.	Standard error	Indicated total birds population index ¹	(Visibility corrected population estimate)	Standard error	% Coefficient of variation	Lower 95% confidence interval	Upper 95% confidence interval
Mallard	0.35	0.07	5210	(20892)	1044	20	3163	7257
Northern pintail	1.60	0.70	23682	(72230)	10341	44	3413	43951
Green-winged teal	0.30	0.04	4379	(36608)	579	13	3244	5514
American wigeon	2.19	0.37	32477	(124712)	5434	17	21827	43127
Northern shoveler	0.35	0.09	5193	(19681)	1288	25	2668	7718
Scaup*	2.16	0.19	32134	(62019)	2756	9	26732	37537
Oldsquaw	0.20	0.03	2935	(5488)	467	16	2020	3849
Black scoter	0.57	0.07	8503	(9949)	1061	13	6423	10583
Surf Scoter	0.03	0.01	494	(578)	190	38	122	866
Red-breasted merganser	0.12	0.06	1828	(2322)	834	46	192	3463
Canada goose*	1.23	0.25	18310	N/A	3657	20	11143	25478
White-fronted goose*	0.76	0.17	11343	N/A	2475	22	6492	16194
Tundra swan*	1.05	0.36	15623	N/A	5369	34	5100	26145
Sandhill crane*	0.10	0.02	1469	N/A	332	23	819	2119
Red-necked grebe*	0.21	0.04	3128	N/A	600	19	1952	4303
Pacific loon*	0.22	0.03	3240	N/A	379	12	2497	3983
Red-throated loon*	0.06	0.01	821	N/A	165	20	497	1145
Jaeger*	0.09	0.01	1401	N/A	213	15	985	1818
Glaucous gull*	0.27	0.08	4032	N/A	1108	28	1860	6203
Mew gull*	0.13	0.02	1925	N/A	307	16	1323	2527
Arctic tern*	0.64	0.09	9512	N/A	1271	13	7021	12003

¹ Population index = $A * T/S$ within each stratum then summed over all strata

A = Square kilometers in survey stratum = 14,848

T = indicated total birds: 2 * (singles + pairs) + flocks in stratum

S = Square kilometers sampled in stratum = 784

* Single birds not doubled to calculate indicated total birds

Standard visibility correction factors: Factors for species other than those listed below have not been determined

Mallard = 4.01, Wigeon = 3.84, Teal = 8.36, Shoveler = 3.79, Pintail = 3.05, Canvasback = 2.43,

Scaup = 1.93, Ring-necked duck = 4.02, Goldeneye = 3.61, Bufflehead = 1.86, Oldsquaw = 1.87,

Scoter = 1.17, Merganser = 1.27

Table 4. Water bird population indices based on 6 strata design (Fig. 3) from June 1997 aerial survey of Selawik National Wildlife Refuge, Alaska.

Species	Birds per sq. km.	Standard error	Indicated total birds population index ¹	(Visibility corrected population estimate)	Standard error	% Coefficient of variation	Lower 95% confidence interval	Upper 95% confidence interval
Mallard	0.29	0.07	4481	(17969)	1000	22	2522	6441
Northern pintail	1.44	0.21	21913	(66835)	3235	15	15573	28253
Green-winged teal	0.15	0.03	2337	(19537)	404	17	1546	3129
American wigeon	0.88	0.11	13402	(51464)	1615	12	10237	16567
Northern shoveler	0.33	0.05	5044	(19117)	695	14	3682	6406
Scaup*	2.06	0.16	31359	(60523)	2360	8	26733	35985
Canvasback	0.04	0.01	534	(1298)	165	31	211	858
Oldsquaw	0.42	0.07	6339	(11854)	1129	18	4125	8553
Black scoter	0.76	0.10	11507	(13463)	1547	13	8476	14538
Surf scoter	0.20	0.07	3052	(3571)	1039	34	1015	5089
Red-breasted merganser	0.10	0.03	1505	(1911)	412	27	698	2313
Canada goose*	0.85	0.12	12963	N/A	1753	14	9526	16399
White-fronted goose*	0.75	0.12	11376	N/A	1848	16	7754	14998
Tundra swan*	0.92	0.32	14024	N/A	4826	34	4565	23483
Sandhill crane*	0.12	0.02	1860	N/A	325	17	1224	2496
Red-necked grebe*	0.16	0.03	2464	N/A	397	16	1686	3242
Pacific loon*	0.16	0.02	2444	N/A	315	13	1826	3062
Jaeger*	0.11	0.02	1658	N/A	271	16	1126	2190
Glaucous gull*	0.29	0.05	4454	N/A	682	15	3118	5790
Mew gull*	0.07	0.03	1019	N/A	475	47	89	1950
Arctic tern*	0.49	0.07	7423	N/A	1124	15	5219	9627

¹ Population index = A * T/S within each stratum then summed over all strata

A = Square kilometers in survey stratum = 15,234

T = indicated total birds: 2 * (singles + pairs) + flocks in stratum

S = Square kilometers sampled in stratum = 832

* Single birds not doubled to calculate indicated total birds

Standard visibility correction factors: Factors for species other than those listed below have not been determined

Mallard = 4.01, Wigeon = 3.84, Teal = 8.36, Shoveler = 3.79, Pintail = 3.05, Canvasback = 2.43,

Scaup = 1.93, Ring-necked duck = 4.02, Goldeneye = 3.61, Bufflehead = 1.86, Oldsquaw = 1.87, Scoter = 1.17, Merganser = 1.27

Table 5. Water bird average population indices based on 6 strata design (Fig. 3) from combined June 1996 and 1997 aerial survey of Selawik National Wildlife Refuge, Alaska.

Species	Birds per sq. km.	Standard error	Indicated total birds population index ¹	(Visibility corrected population estimate)	Standard error	% Coefficient of variation	Lower 95% confidence interval	Upper 95% confidence interval
Mallard	0.32	0.05	4861	(19493)	714	15	3462	6261
Northern pintail	1.50	0.35	22919	(69903)	5317	23	12498	33339
Green-winged teal	0.22	0.03	3404	(28457)	402	12	2617	4191
American wigeon	1.49	0.20	22637	(86926)	2971	13	16813	28461
Northern shoveler	0.34	0.05	5120	(19405)	712	14	3725	6515
Scaup*	2.10	0.12	31911	(61588)	1824	6	28336	35485
Canvasback	0.02	0.01	330	(802)	99	30	137	523
Oldsquaw	0.32	0.04	4815	(9004)	671	14	3500	6130
Black scoter	0.66	0.06	10094	(11810)	944	9	8244	11944
Surf scoter	0.12	0.03	1767	(2067)	507	29	773	2761
Common merganser	0.02	0.01	329	(418)	147	45	40	617
Red-breasted merganser	0.11	0.03	1681	(2135)	448	27	802	2560
Canada goose*	1.02	0.13	15519	N/A	2001	13	11597	19441
White-fronted goose*	0.75	0.01	11367	N/A	1532	14	8364	14370
Tundra swan*	0.99	0.23	15030	N/A	3563	24	8046	22014
Sandhill crane*	0.11	0.02	1692	N/A	236	14	1230	2154
Red-necked grebe*	0.18	0.02	2791	N/A	359	13	2088	3494
Pacific loon*	0.19	0.02	2894	N/A	258	9	2388	3400
Red-throated loon	0.03	0.01	507	N/A	92	18	326	688
Jaeger*	0.11	0.02	1628	N/A	224	14	1188	2067
Glaucous gull*	0.30	0.04	4526	N/A	666	15	3221	5831
Mew gull*	0.10	0.02	1484	N/A	295	20	907	2062
Arctic tern*	0.56	0.06	8549	N/A	891	10	6802	10296

¹ Population index = A * T/S within each stratum then summed over all strata

A = Square kilometers in survey stratum = 15,234

T = indicated total birds: 2 * (singles + pairs) + flocks in stratum

S = Square kilometers sampled in stratum = 1,616

* Single birds not doubled to calculate indicated total birds

Standard visibility correction factors: Factors for species other than those listed below have not been determined

Mallard = 4.01, Wigeon = 3.84, Teal = 8.36, Shoveler = 3.79, Pintail = 3.05, Canvasback = 2.43,

Scaup = 1.93, Ring-necked duck = 4.02, Goldeneye = 3.61, Bufflehead = 1.86, Oldsquaw = 1.87, Scoter = 1.17, Merganser = 1.27

Table 6. Comparison of densities¹ (per sq. km) for selected species and total ducks from spring aerial surveys on 7 survey areas in Alaska.

Species or group	Survey Area						
	Yukon Delta NWR ²	Yukon Flats NWR ³	Arctic coastal plain ⁴	Bristol Bay region ⁵	southern unit Innoko NWR ⁶	northern unit Innoko NWR and Yukon River wetlands ⁷	Selawik NWR/Noatak Lowlands ⁸
Northern pintail	4.7	3.0	3.4	1.1	3.1	1.7	4.6
Mallard	1.0	3.4	0.5	0.9	0.5	1.7	1.3
Green-winged teal	1.9	1.8	0.1	1.0	2.3	3.7	1.9
American wigeon	1.1	3.1	0.1	0.4	1.8	3.2	5.7
Northern shoveler	1.3	2.5	--	0.3	1.1	1.5	1.3
Canvasback	0.1	1.5	--	--	--	0.1	--
Scaup	2.8	6.1	0.4	1.9	1.3	1.2	4.0
Oldsquaw	0.5	0.1	1.5	0.1	--	--	0.6
Scoter	1.2	1.9	0.2	1.0	0.5	0.1	0.9
Total ducks	16.0	24.0	6.0	7.0	11.0	13.2	20.5

¹ Densities are based on indicated total birds (except for scaup) corrected for visibility bias and calculated as average of mean annual densities.

² Surveys from 1989-1992

³ Surveys from 1989-1991

⁴ Surveys from 1986-1990

⁵ Surveys from 1993-1994

⁶ Survey in 1994

⁷ Survey in 1995

⁸ Surveys from 1996-1997

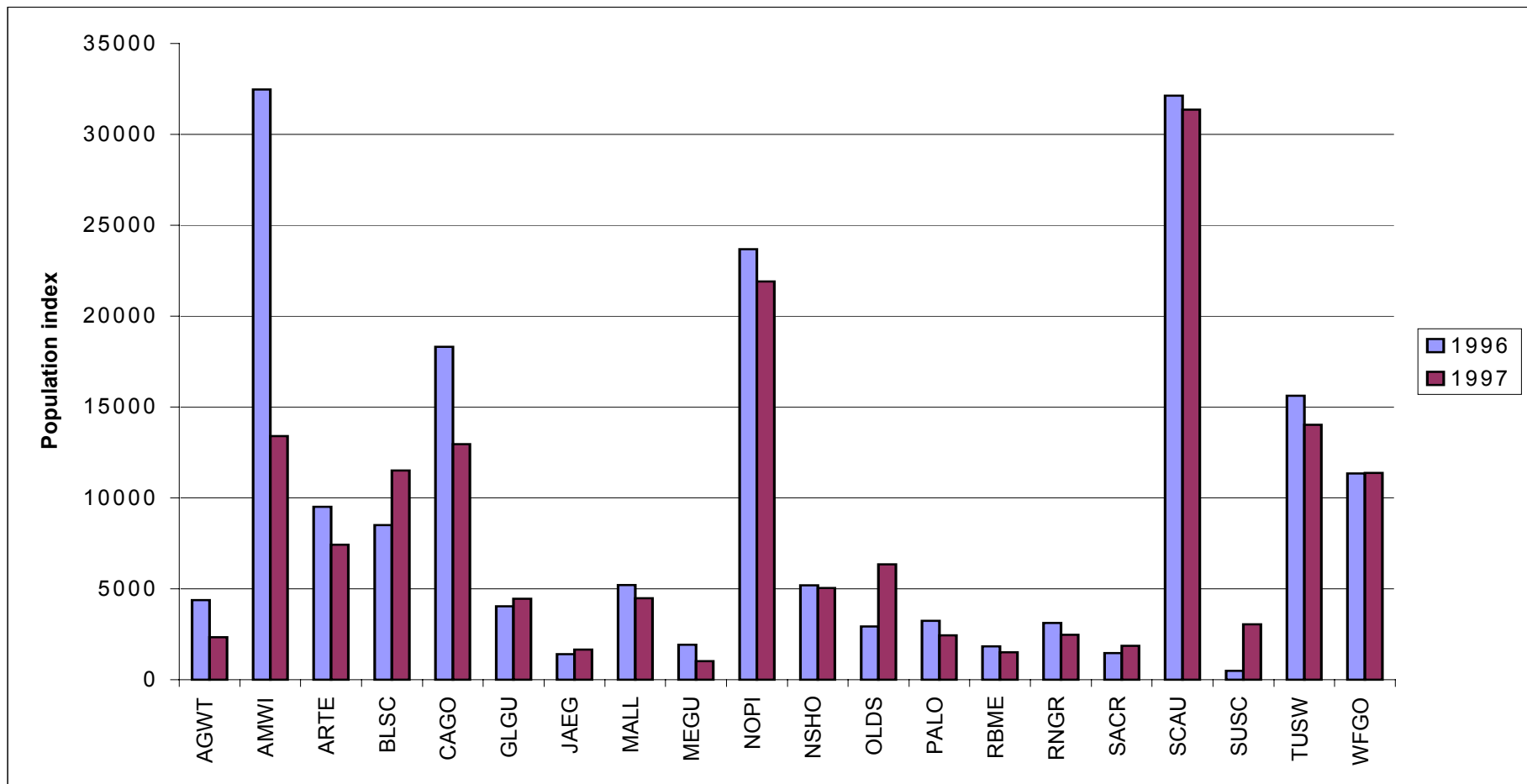


Fig. A. Population indices for water bird species observed on June aerial surveys of Selawik National Wildlife Refuge and the Noatak Lowlands in 1996 and 1997.

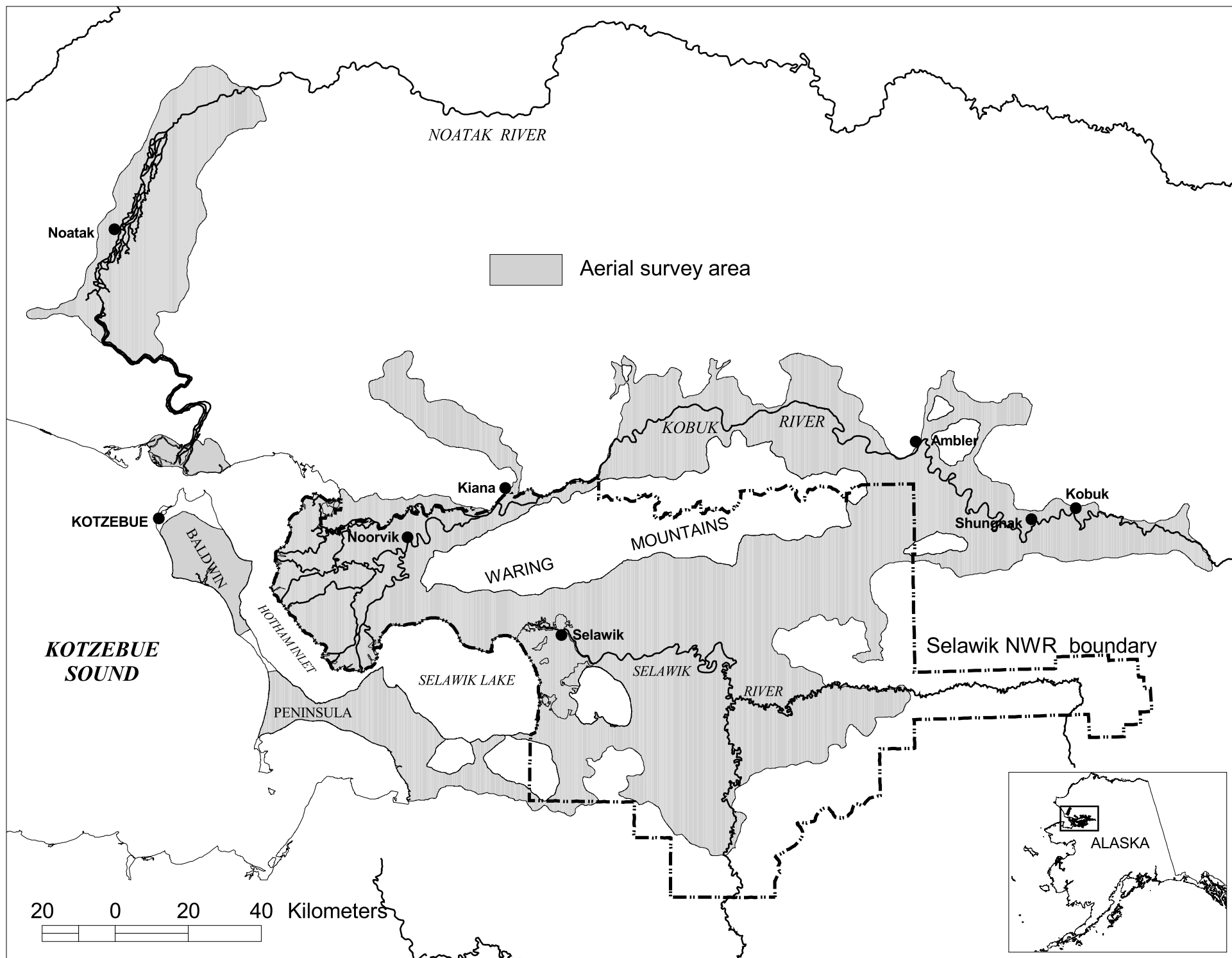


Fig. 1. Expanded waterfowl breeding pair survey area in relation to Selawik National Wildlife Refuge, Alaska.